ECE/CS 5565: Project1
Fall 2024

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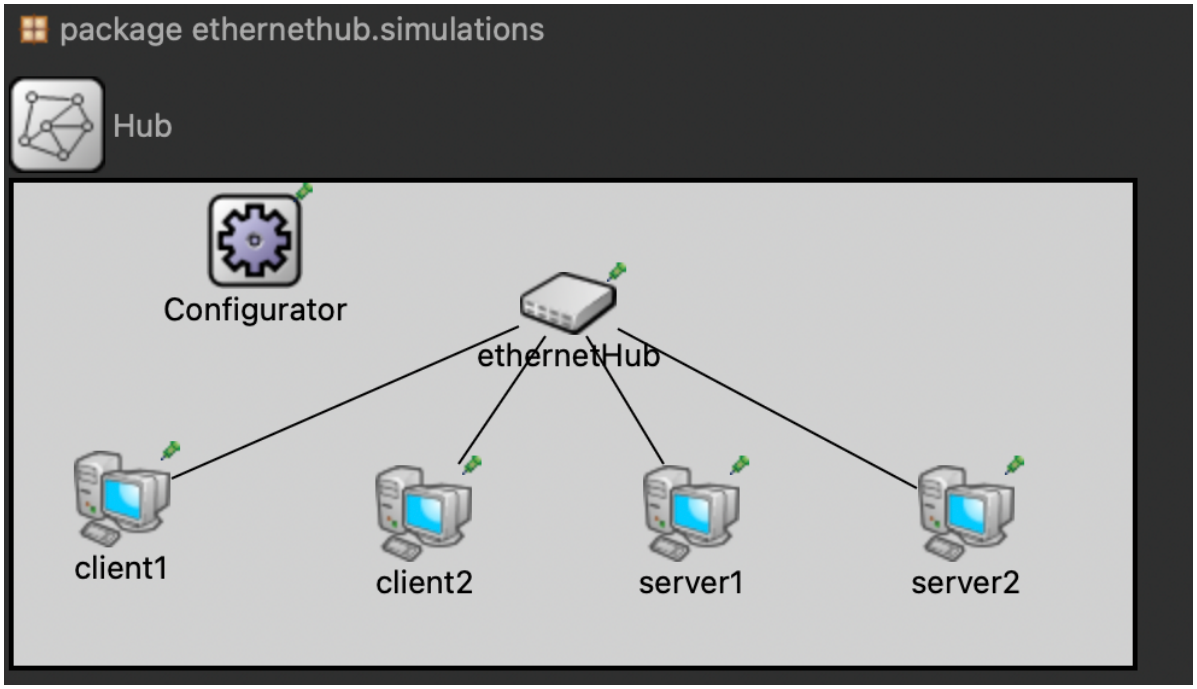
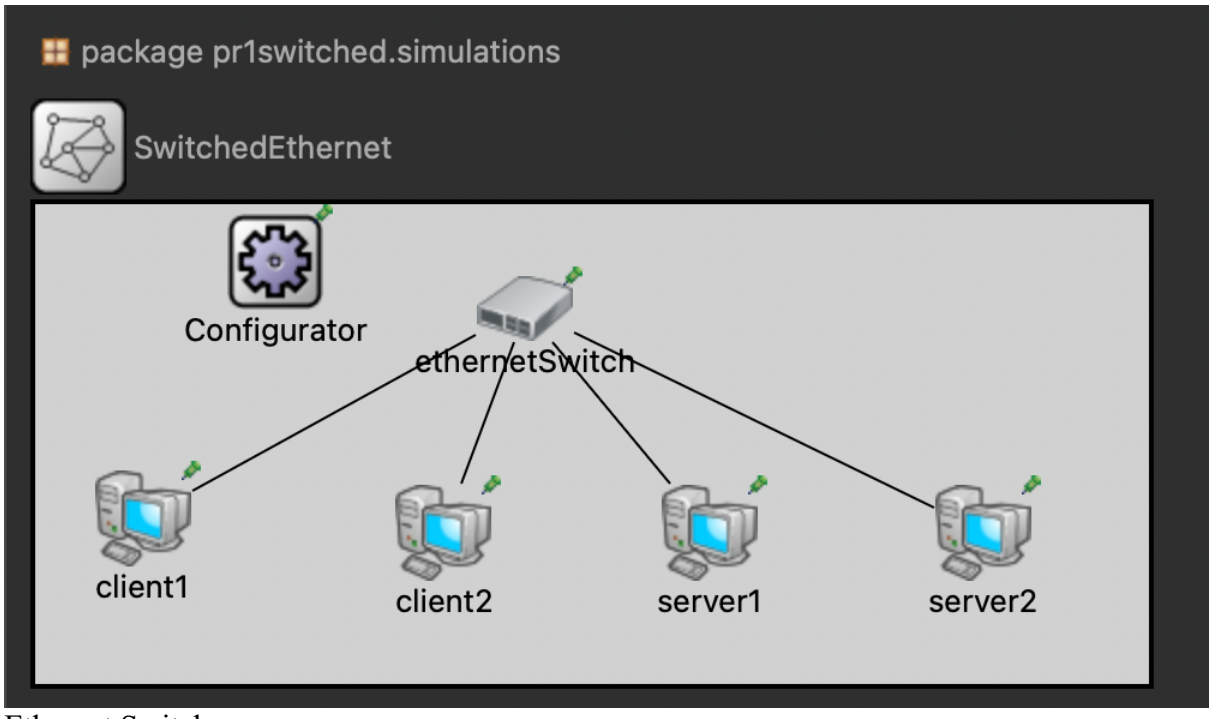
1. **Network Simulation**
   1.1 Network image



EthernetHub



Ethernet Switch

1.2 Numerical Results Table

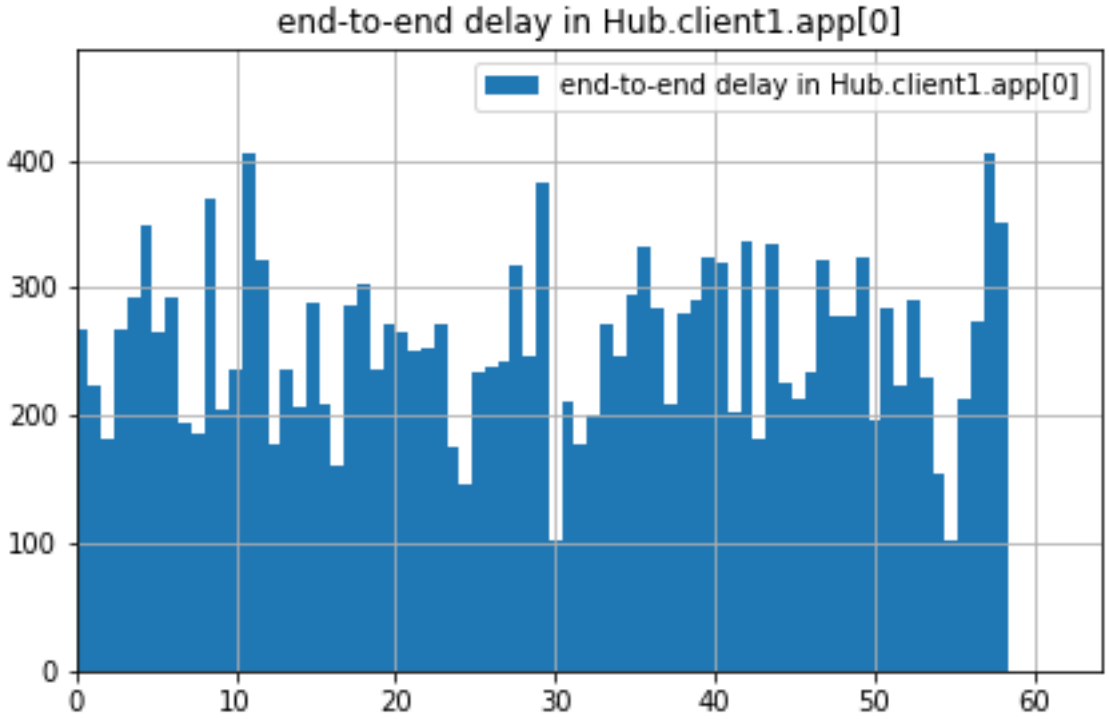
EthernetHub

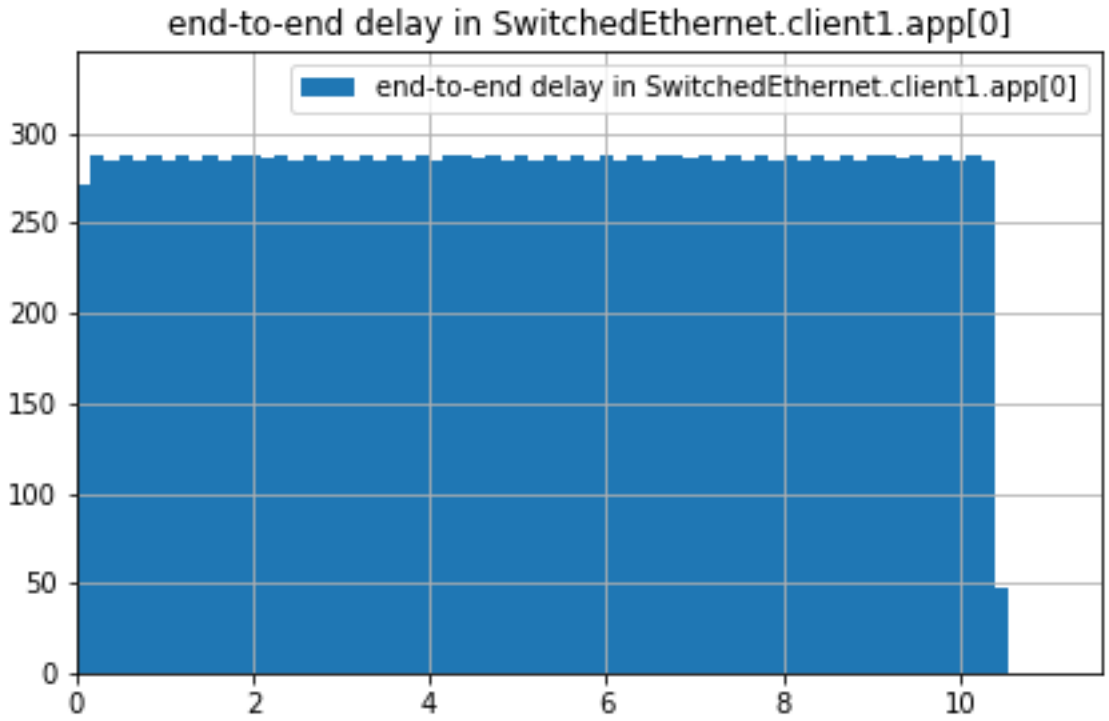
Field	Value
Module name	Hub.client1.app[0]
Mean	29.334582
StdDev	17.007569

SwitchedEthernet

Field	Value
Module name	SwitchedEthernet.client1.app[0]
Mean	5.216841
StdDev	3.007523

1.3 Histograms


end-to-end delay in Hub.client1.app[0]
end-to-end delay in Hub.client1.app[0]
400
300
200
100
0
0
10
20
30
40
50
60


end-to-end delay in SwitchedEthernet.client1.app[0]
end-to-end delay in SwitchedEthernet.client1.app[0]
300
250
200
150
100
50
0
0
2
4
6
8
10

1.4 Comparison

We found that Hub has a higher latency as compared to the switch. We also found that the standard deviation was highly visible in the fluctuations and end-to-end delays.

An Ethernet switch operates at the data link layer, ensuring data is sent only to the intended recipient's port. Each port operates independently, reducing the chance of data collisions and retransmissions.

The results clearly indicate a significant performance difference between the Ethernet Hub and the Switched Ethernet configurations. For the Switched Ethernet, the mean latency is 5.216841 with a standard deviation of 3.007523, highlighting lower overall delays and a more stable transmission performance.

In contrast, the Ethernet Hub shows a much higher mean latency of 29.334582, accompanied by a considerably larger standard deviation of 17.007569. This higher latency and greater variability in the hub's performance are likely due to increased data collisions and retransmissions, which occur when the hub broadcasts data to all connected devices, resulting in inefficient handling of network traffic.

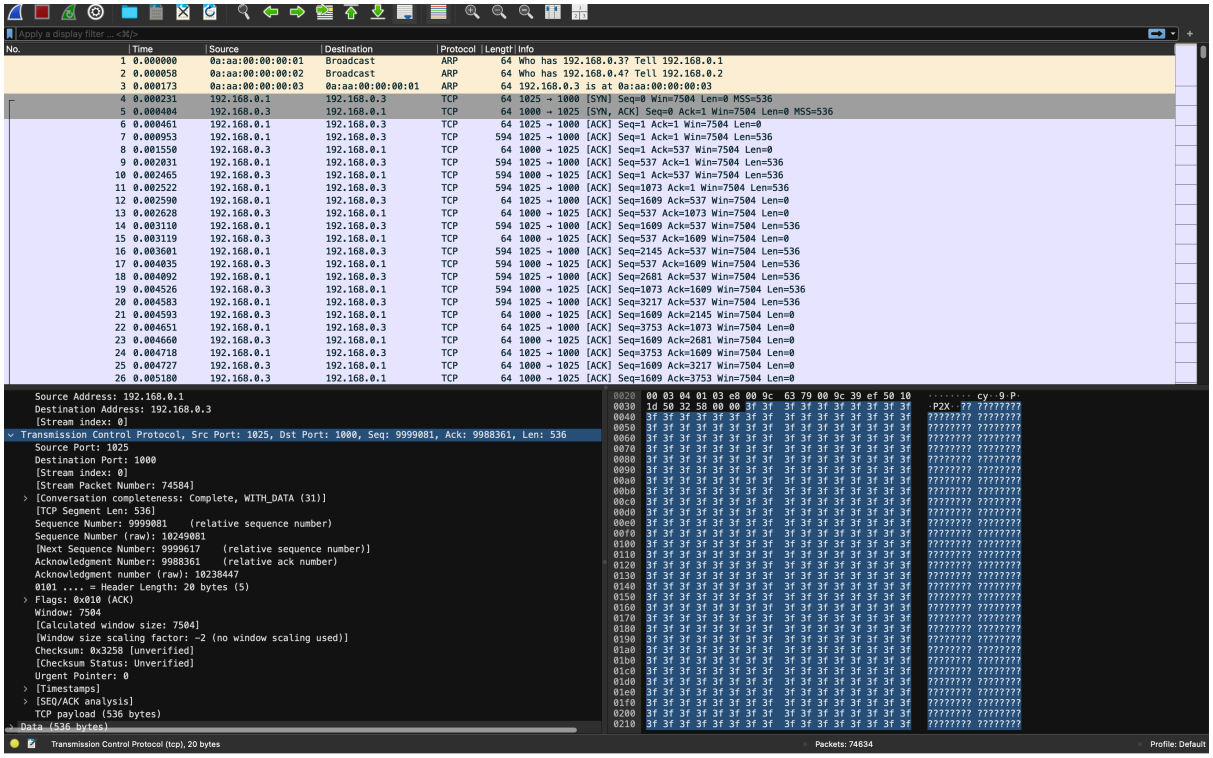
These differences show the efficiency of switches, which, by directing traffic to the appropriate port and reducing the risk of collisions, ensures smoother communication with significantly lower and more consistent latency values.

1.5 Discussion

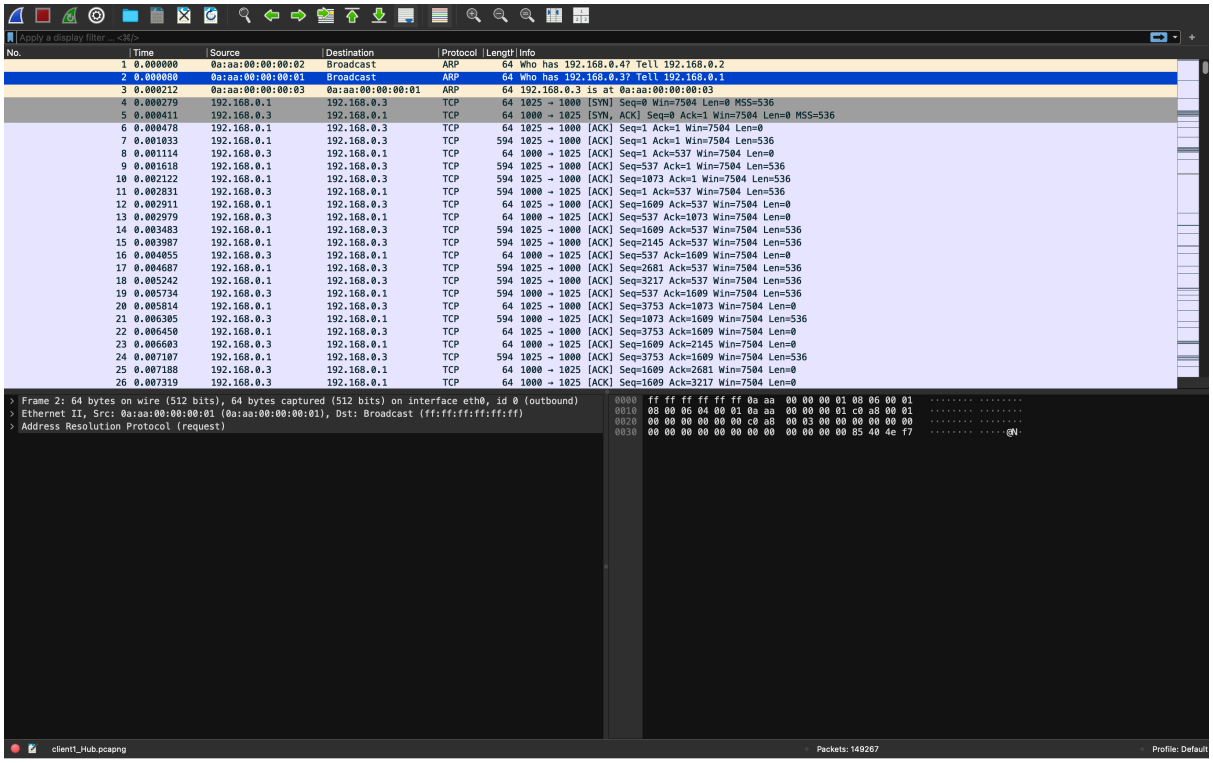
The only problem encountered was during the OMNET++ installation in Mac the Rosetta setup was tricky.

2. Wireshark

2.1 Wireshark Images



Ethernet Switch



Ethernet Hub

2.2 Ethernet Switch Networking Questions

a

Server1 0a:aa:00:00:00:03
Client1 0a:aa:00:00:00:01
Client2 1 0a:aa:00:00:00:02
Server2 0a:aa:00:00:00:04

b.

Client1: 192.168.01
Client2: 192.168.02
Server1: 192.168.03
Server2: 192.168.04

c.
ARP protocol is used in frames1,2 and 3.
Frames 1 and 2 are ARP requests, where devices with IP addresses 192.168.0.1 and 192.168.0.2 are asking for the MAC addresses corresponding to IPs 192.168.0.3 and 192.168.0.4, respectively. Frame 3 is an ARP reply from the device with IP 192.168.0.3, providing its MAC address (0a:aa:00:00:00:03) to the device that requested it.

d.

Frames 4, 5, and 6 represent the TCP three-way handshake, which establishes a reliable connection between two devices:

- Frame 4: A TCP SYN packet from `192.168.0.1` to `192.168.0.3`, initiating the connection (Seq=0).
- Frame 5**:** A TCP SYN-ACK packet from `192.168.0.3` to `192.168.0.1`, acknowledging the SYN and synchronizing the connection (Seq=0, Ack=1).
- Frame 6: A TCP ACK packet from `192.168.0.1` to `192.168.0.3`, completing the handshake (Seq=1, Ack=1).

e.

Frame7:

Time recorded at 0.000953000s

f.

Frame:74633
10.425444

746…	10.421435	192.168.0.3	192.168.0.1	TCP	64	1000 → 1025 [ACK] Seq=9995865 Ack=9998545 Win=7504 Len=0
746…	10.421502	192.168.0.3	192.168.0.1	TCP	64	1000 → 1025 [ACK] Seq=9995865 Ack=9999081 Win=7504 Len=0
746…	10.421569	192.168.0.3	192.168.0.1	TCP	64	1000 → 1025 [ACK] Seq=9995865 Ack=9999617 Win=7504 Len=0
746…	10.421636	192.168.0.3	192.168.0.1	TCP	64	1000 → 1025 [ACK] Seq=9995865 Ack=10000002 Win=7504 Len=0
746…	10.422128	192.168.0.3	192.168.0.1	TCP	594	1000 → 1025 [ACK] Seq=9995865 Ack=10000002 Win=7504 Len=536
746…	10.422185	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=9996401 Win=7504 Len=0
746…	10.422619	192.168.0.3	192.168.0.1	TCP	594	1000 → 1025 [ACK] Seq=9996401 Ack=10000002 Win=7504 Len=536
746…	10.422676	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=9996937 Win=7504 Len=0
746…	10.423110	192.168.0.3	192.168.0.1	TCP	594	1000 → 1025 [ACK] Seq=9996937 Ack=10000002 Win=7504 Len=536
746…	10.423168	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=9997473 Win=7504 Len=0
746…	10.423601	192.168.0.3	192.168.0.1	TCP	594	1000 → 1025 [ACK] Seq=9997473 Ack=10000002 Win=7504 Len=536
746…	10.423659	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=9998009 Win=7504 Len=0
746…	10.424092	192.168.0.3	192.168.0.1	TCP	594	1000 → 1025 [ACK] Seq=9998009 Ack=10000002 Win=7504 Len=536
746…	10.424150	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=9998545 Win=7504 Len=0
746…	10.424584	192.168.0.3	192.168.0.1	TCP	594	1000 → 1025 [ACK] Seq=9998545 Ack=10000002 Win=7504 Len=536
746…	10.424641	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=9999081 Win=7504 Len=0
746…	10.425075	192.168.0.3	192.168.0.1	TCP	594	1000 → 1025 [ACK] Seq=9999081 Ack=10000002 Win=7504 Len=536
746…	10.425132	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=9999617 Win=7504 Len=0
746…	10.425444	192.168.0.3	192.168.0.1	TCP	442	1000 → 1025 [FIN, ACK] Seq=9999617 Ack=10000002 Win=7504 Len=384
746…	10.425502	192.168.0.1	192.168.0.3	TCP	64	1025 → 1000 [ACK] Seq=10000002 Ack=10000002 Win=7504 Len=0

g.

Ethernet II, Src: 0a:aa:00:00:00:03 (0a:aa:00:00:00:03)
Dst: 0a:aa:00:00:00:01 (0a:aa:00:00:00:01)

Internet Protocol Version 4, Src: 192.168.0.3, Dst: 192.168.0.1

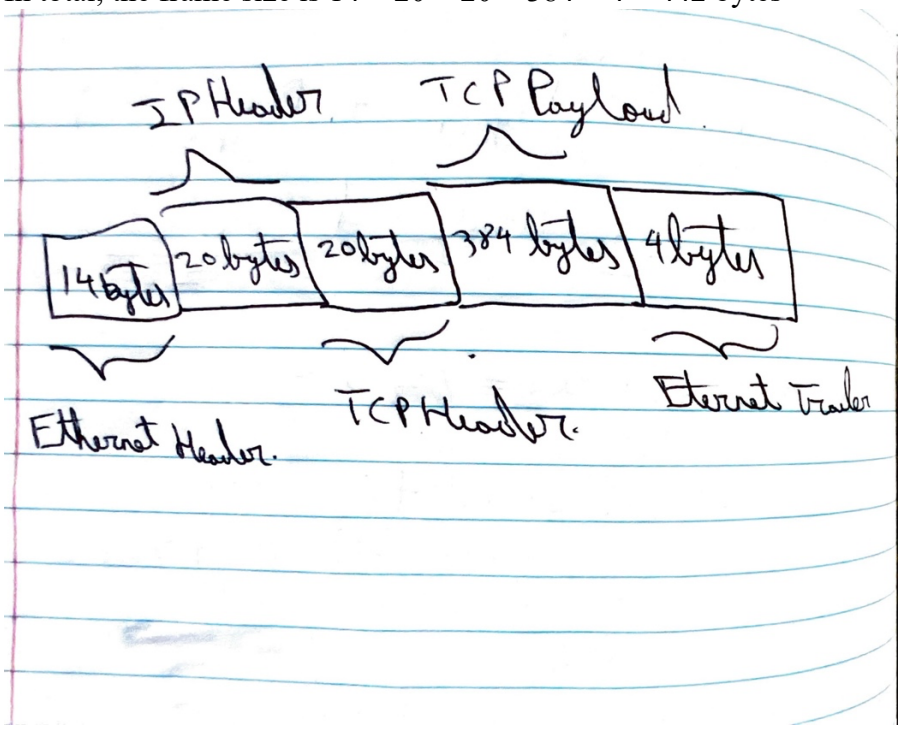
Transmission Control Protocol, Src Port: 1000, Dst Port: 1025

h.

Breakdown of Sizes:

- Ethernet II Header: 14 bytes
- IP Header: 20 bytes
- TCP Header: 20 bytes
- TCP Payload: 384 bytes
- Ethernet Trailer: 4 bytes

In total, the frame size is 14 + 20 + 20 + 384 + 4 = 442 bytes



i.

Bytes transferred from Client1 to Server1: 12 MB. This includes all header bytes (Ethernet, IP, and TCP headers).
Duration of the conversation: 10.4253 seconds.
Effective bit rate from Client1 to Server1: 9420 kbps.

2.3 EthernetHub

Client1: 0a:aa:00:00:00:01
Client2: 0a:aa:00:00:00:02 Server1: 0a:aa:00:00:00:03 Server2: 0a:aa:00:00:00:04

a.
Frame 7
T= 0.001033s

b.
Frame 147424
T=58.348568s

c.
Bytes transferred from Client1 to Server1: 12 MB. This includes all header bytes (Ethernet, IP, and TCP headers).
Duration of the conversation: 58.3527 seconds.
Effective bit rate from Client1 to Server1: 1683 kbps.

2.4 Comparison

In both cases, the same amount of data was transferred, but the performance differed significantly. The Ethernet hub exhibited a longer duration and a lower effective bit rate of 1683 kbps, compared to the Ethernet switch's significantly higher bit rate of 9420 kbps. The Ethernet switch achieves a higher throughput and better efficiency by sending data only to the intended recipient port, which optimizes bandwidth usage and minimizes collisions and retransmissions. In contrast, the Ethernet hub broadcasts data to all connected ports indiscriminately, leading to increased collisions and retransmissions, which degrade performance and reduce efficiency.

2.5 Discussion

I didn't encounter any problems in the Wireshark part.

Key References

• *OMNeT++ Discrete Event Simulator: https://omnetpp.org/*
• *INET Framework: https://inet.omnetpp.org/*
• *"Getting Started with INET | OMNeT++ Tutorial" on YouTube: https://youtu.be/ujQ_jaItx_Y*
• *Wireshark Network Protocol Analyzer: https://www.wireshark.org/*